Energy Savings Opportunities for Existing Buildings

An AB 549 Final Project Report

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HMG Project #0304

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BACKGROUND

In the 2000-2001 Legislative Session, Assembly Member John Longville introduced a bill targeted at improving the energy efficiency of existing buildings. Whereas the State of California has an energy code in force that regulates new construction, this directive from the legislature addresses the millions of existing buildings that are less efficient and consume far greater energy than do newly constructed buildings. This bill requires the California Energy Commission (CEC) to conduct a study and provide recommendations for how to save energy and to reduce peak demand in existing residential and nonresidential buildings as a Report to the Legislature.

In response to the AB 549 mandate, the CEC is developing an Action Plan for the legislature. The Action Plan will outline a set of integrated strategies that will cost-effectively reduce peak and overall energy use in existing residential and nonresidential buildings in California. These strategies are likely to include both mandatory approaches, such as new standards, and voluntary strategies, such as market-based programs to support better decision-making by consumers and contractors.

Southern California Edison, in cooperation with all of the Investor Owned Utilities (IOUs), San Diego Gas & Electric, Southern California Gas Company, and Pacific Gas & Electric, supported the CEC's effort by providing research, analysis and recommendations on cost-effective, market-ready regulatory strategies to consider as part of the overall effort. In some cases, the recommendations are ready to incorporate into a code revision. In other cases, some additional research must be done, additional market support must be in place or new authority must be obtained before regulatory action can be taken.

The first interim report for this project, Markets and Potential, identified characteristics of the existing building market in order to identify areas of opportunity for saving energy in existing buildings. Highlights from the report include:

1. Seventy-two percent of the existing residential building stock pre-dates the Building Energy Efficiency Standards

2. Fifty-seven percent of the existing nonresidential building stock pre-dates the Buildings Energy Efficiency Standards

3. The Appliance Efficiency Standards and the Building Energy Efficiency Standards are successful at improving existing building stock to the extent they are evoked. The 2005 standards will generate 216 GWh and 71 MW of energy and demand savings in the first year alone in the additions and alterations market.

4. Even given savings from the standards and utility incentive programs, the savings potential in this market is significant. The energy savings potential is estimated to exceed 10,000 GWh/year. The demand savings potential is estimated to exceed 2000 MW/year.

The second interim report, Events and Measures, provided a set of recommended strategies for mandatory approaches to improving energy efficiency in the existing buildings market. The report detailed key events in the life of an existing building that are opportunities for energy efficiency improvements, and provided a list of promising energy efficiency measures and potential mandatory mechanisms that could be used to enact those measures.

The report's conclusions were:

1. Several criteria must be present in order for a regulatory option to work well. These criteria include:
   - measure technical and economic feasibility
   - measure market readiness
   - a well-defined trigger event
   - authority to take action at the identified trigger event
   - a well-planned administrative mechanism to regulate, enforce and document the recommended action
   - cooperation from key players and stakeholders
2. There are already two very effective mechanisms in place that are improving the efficiency of new buildings – the Building Energy Efficiency Standards and the Appliance Efficiency Standards.
3. The report identified eight trigger events that should be considered to leverage more energy savings from existing buildings. Some of these events currently evoke building or appliance efficiency standard regulations and some do not.
4. It identified five new measure ideas for existing mechanisms (the Building Energy Efficiency Standards and the Appliance Efficiency Standards).
5. It identified 11 individual measures that could be considered during a time of sale trigger event.
6. It identified three sets of integrated strategies that could be developed with regulatory and voluntary support, leading to market acceptance and evolution into regulation.
7. It identified other measures that, with additional voluntary support, could eventually be moved to the regulatory marketplace.

This document, the Final Project Report, summarizes information from the prior reports, identifies the top candidate recommendations and provides statewide savings estimates.

1. PROCESS

1.1 Understanding the Savings Potential

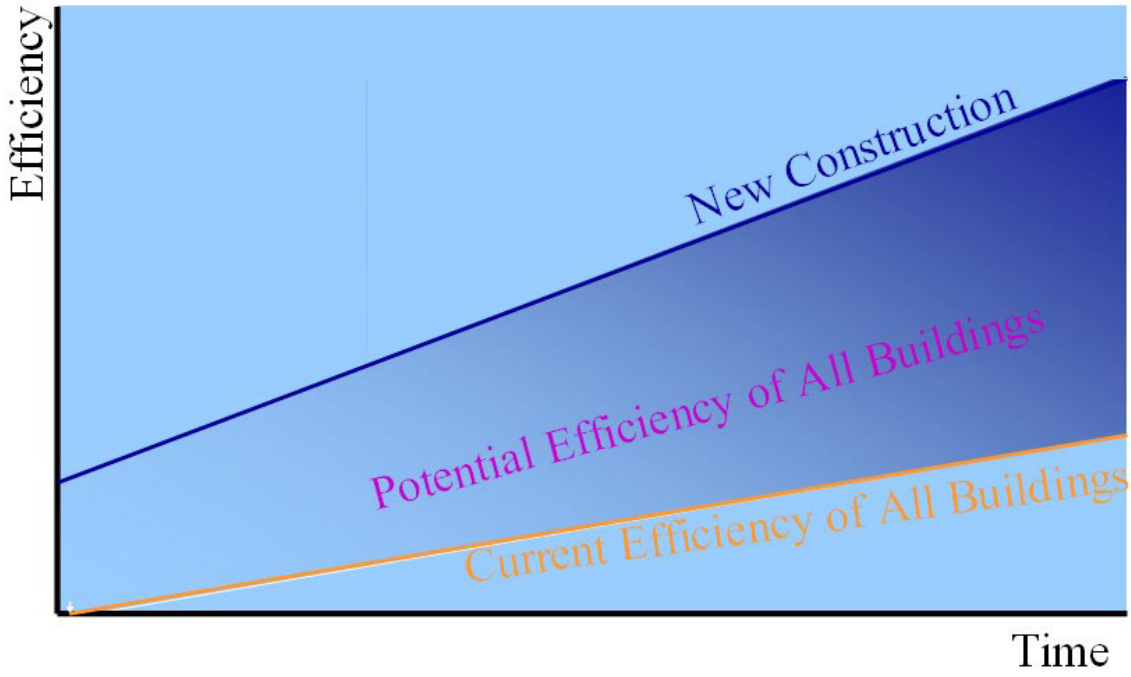
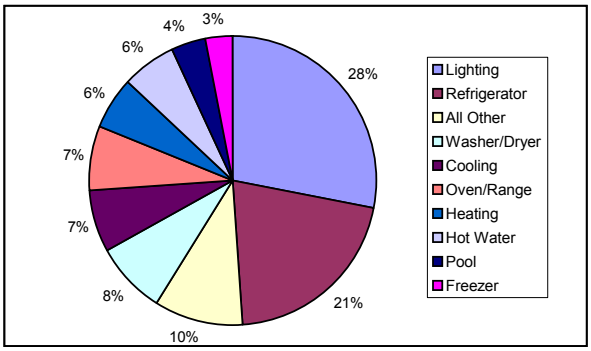


Figure 1: Savings Potential Concept Sketch

This concept sketch illustrates the gap between the efficiency of existing housing stock and new construction. The gap represents the potential impact that an effective set of strategies could have on existing building stock. Influenced by the Building Energy Efficiency Standards, new construction has the greatest potential for energy efficiency improvement (slope of the curve) as time progresses and standards updates are made. New technologies are easy to incorporate into new buildings that impact the efficiency of the new construction market, while the existing building stock has a higher barrier to improvement, and therefore a lower potential improvement. Existing stock improves over time due to two factors: One, appliances are replaced with substantially more efficient ones due to the influence of the Appliance Efficiency Standards and utility retrofit programs. Two, alterations are made that evoke the Building Energy Efficiency Standards. Over time, the average efficiency of existing stock increases slightly because newer, more efficient stock is folded into the total stock each year, increasing the proportion of efficient buildings vs. inefficient ones. Other factors such as improved operation, commissioning, and ongoing maintenance can also improve performance of existing stock. It is possible that over time, under optimum conditions, the existing market can approach and possibly even surpass the level of efficiency of the new construction market, as shown in the shaded area

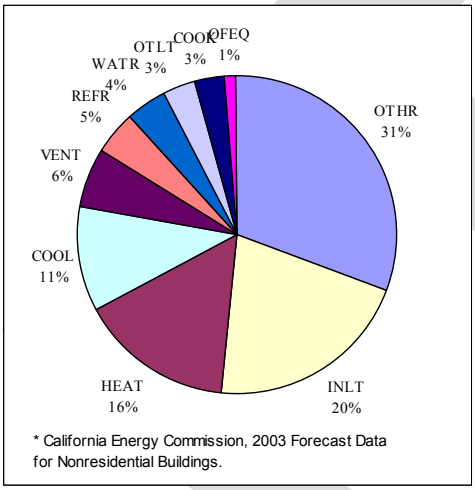
labeled “potential efficiency of all buildings”. However, the efficiency curve of new buildings is seen as an upper threshold, beyond which it may be more cost effective to build a new building.

1.2 Targeting End Uses and Measures



Heschong Mahone Group, Lighting and Efficiency Technology Report, Volume I: California Baseline 1997

Figure 2: Residential Electrical Use, By End Use, California 1992



* California Energy Commission, 2003 Forecast Data for Nonresidential Buildings.

Figure 3: Commercial Energy End Use for 2002

In order to identify end uses to target for energy savings, it is first necessary to understand how energy is currently being used in the residential and commercial sectors. The end use profile for residential buildings suggests that lighting and air conditioning measures should be targeted, since they will yield proportionally greater results. For commercial buildings, interior lighting and HVAC should be targeted.

1.3 Identifying Trigger Events

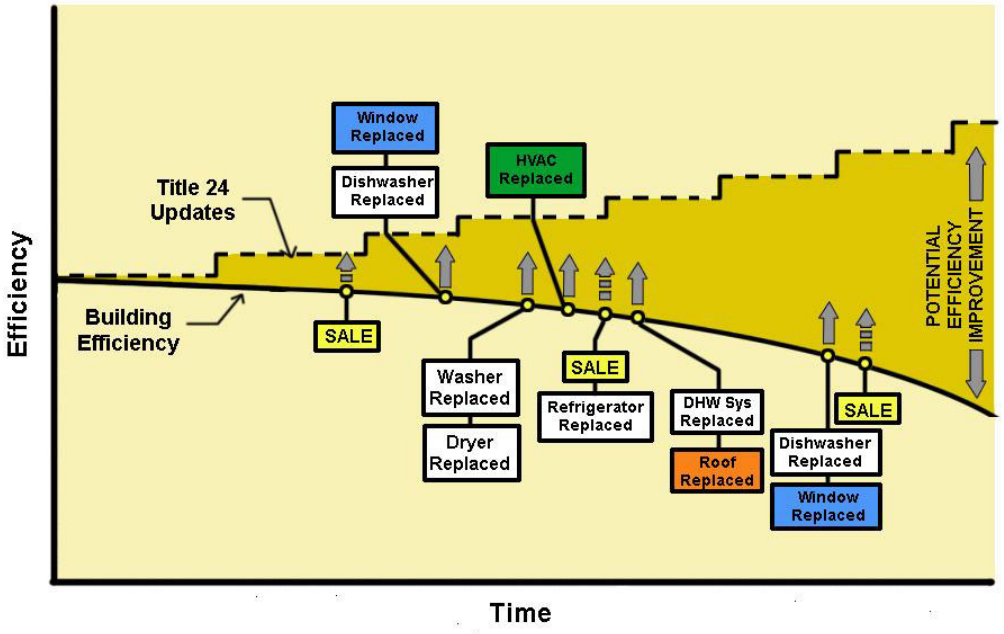


Figure 4: Effect of Residential Events on the Efficiency of an Individual Building Concept Sketch

This concept drawing illustrates some examples of key events that would affect the energy use of an individual residential building. Some events, like the breakdown of appliances, cause them to be replaced. When replaced, the overall building energy use is improved. Beginning in 2006, events such as the replacement of the HVAC unit will require an improvement not only in the efficiency of the unit when compared to the existing, but also of the duct system serving that unit.

Other events that currently do not evoke the building or appliance standard, such as residential roof replacement, could be considered a potential trigger event under the next revision of the Building Energy Efficiency Standards. Cool roofs, attic insulation, or radiant barriers could be required at the time given current Building Standards authority.

In order to require energy efficiency improvements at the time of building sale, new authority would need to be obtained.

Before determining whether or not to require a particular measure or set of measures be installed in an existing building, the measure(s) must be evaluated in the context of the trigger event and mechanism by which they may be regulated. The figure below illustrates the decision process that should be followed for a successful mandate to be developed for each specific measure in a particular market. In many cases, voluntary alternatives may be more appropriate.

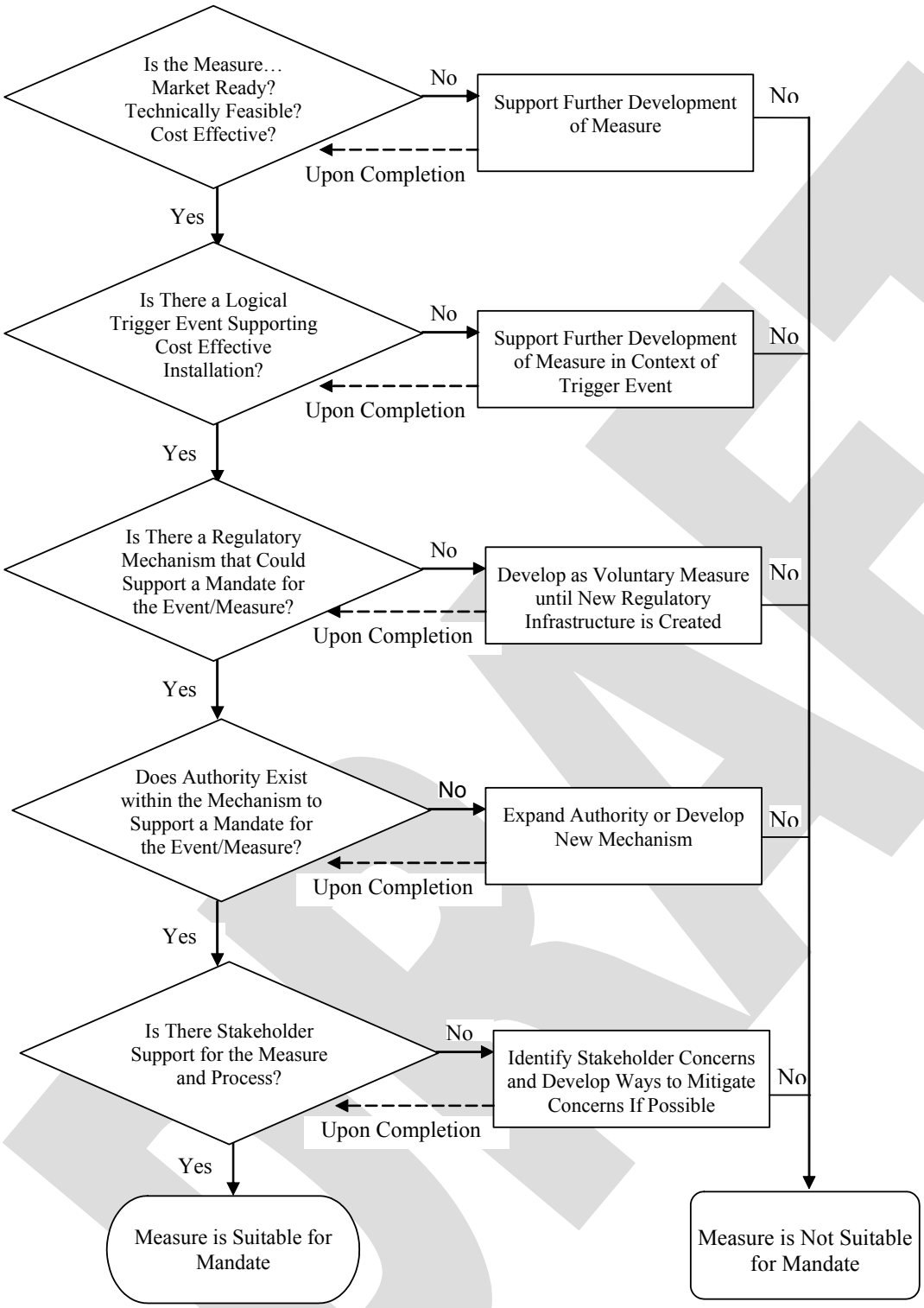


Figure 5: Decision Tree for Measure Suitability

2. OPPORTUNITIES

2.1 Expand Building Standards Regulations

Well-established mechanisms to implement energy efficiency improvements are needed to produce effective regulation. The Title 24 Building Energy Efficiency Standards is one such mechanism. When buildings are altered, the Building Energy Efficiency Standards are evoked. New regulations are periodically adopted through an established process that utilizes standardized cost effectiveness evaluation criteria, peer review and acceptance with stakeholder input. Since the enforcement channel is well established (local building code officials), implementation is relatively easy.

2.2 Expand Appliance Standards Regulations

Another well-established mechanism is provided by the Title 20 Appliance Efficiency Standards. When any covered appliance, space conditioning, water heating, or lighting equipment is sold in California, it is governed by these standards. California enforces federally-mandated standards which cover appliances like refrigerators, air conditioners, heat pumps, water and pool heaters, lamps, fluorescent lamp ballasts dishwashers and clothes washers and dryers. California has the authority to regulate appliances and equipment that is not covered by federal standards. Some examples of these are commercial refrigerators, refrigerated beverage vending machines, ground-source and groundwater-source heat pumps, and non-packaged boilers 300,000 Btu/hour or greater.

New regulations can be adopted under the provisions of Title 20 relatively quickly through an established process that utilizes standardized cost effectiveness criteria, review and acceptance through a public process.

2.3 Leverage the Success of Locally Adopted Time-of-Sale Retrofit Ordinances

It is not within the current authority of the California Energy Commission to require local governments to develop or adopt new ordinances. If there is insufficient political will to directly mandate the required new ordinances, a voluntary approach may be just as effective in the short term. If the State and the Investor-Owned Utilities (IOU's) provided a concentrated amount of technical assistance to local governments and supported local code-adoption efforts in a high profile way, local governments may be more likely to adopt a set of mandates with common features. An ordinance template or toolkit can be developed that cities and counties could review, modify and adopt for their local

jurisdiction. Momentum would build up over time, through State-coordinated technical support and training to encourage this effort.

2.4 Leverage the Success of Home Energy Rating Systems (HERS) Efforts

Building energy efficiency improvements do not always require new equipment to be installed. The Energy Commission has the responsibility to provide oversight and to standardize the Home Efficiency Rating System (HERS) process in California. The Commission adopted regulations for HERS raters to perform Title 24 field verification of certain efficiency measure installations, including, for example, duct testing and sealing. Although these verifications do not constitute ratings, ratings can be used in a variety of ways to motivate building owners to accomplish cost effective energy efficiency improvements. As awareness of relative performance differences among buildings increases, owners are more likely to take voluntary action. Also, as the number of HERS evaluations increases, the data could be used to compile energy efficiency information that can be factored into property appraisals. A HERS rating could be required upon resale if the appropriate authority were granted. HERS ratings can be performed with less than 2 days turnaround. HERS raters are commonly used with residential "Energy Efficient Mortgage" (EEM) programs that provide additional capital in escrow to implement efficiency upgrades.

2.5 Create New Authority to Regulate Residential Buildings at Time of Sale or Ownership Transfer

Building sale or ownership transfer is a very cost-effective time to install certain basic energy efficiency measures, if those measures are not already present in a home. Since the majority of the existing residential building stock was built prior to the standards and the saturation level of naturally occurring upgrades is not that high, there are a significant number of older homes that lack basic energy efficiency features such as ceiling insulation, duct insulation or water heater blankets. HERS ratings and Energy Efficient Mortgages are an important tool for improving energy efficiency at time of sale.

2.6 Leverage the Success and Potential of Building Retrocommissioning Efforts

The commissioning industry for nonresidential buildings has gained a lot of momentum in the last few years, fueled by the efforts of the California Commissioning Collaborative and others. The Collaborative's purpose is to facilitate the development of cost effective programs, tools, techniques and

service delivery infrastructure that enables the implementation of the building commissioning process in newly constructed and existing buildings.[1]

This collaborative could be part of a working group to assist in determining how and under what circumstances building commissioning or retrocommissioning would be practical and cost effective for a statewide mandate. The potential in large commercial office buildings is significant, approaching 136 GWh annually.

2.7 Create New Authority to Regulate Commercial Buildings at the Time of Sale or Ownership Transfer

Building sale or ownership transfer of nonresidential buildings, in many cases, provides a good trigger event to install certain basic equipment such as demand-responsive lighting controls or appliance tune-up and can result in a significant amount of energy savings. Certain nonresidential occupancies like office buildings, groceries hospitals and hotels can benefit the most from these basic retrofits, which are relatively noninvasive yet generate immediate energy and demand savings with payback periods less than 3 years, in many cases. The Energy Services Company (ESCO) industry has grown up around the many lucrative opportunities afforded by equipment and lighting retrofits.

[1] For more information, visit http://www.cacx.org/

3. IDENTIFICATION AND EVALUATION OF MEASURES

The figures below summarize the statewide savings estimates for the measures evaluated in this section. The measures are sorted by relative potential energy savings. Home Energy Ratings, when combined with Energy Efficient Mortgages, carry the highest energy savings potential. There was not enough data to evaluate the demand impact of Home Energy Ratings. Some residential measures like shading, whole house fans and replacement pool pumps show great promise for both energy savings and demand savings. In commercial buildings, retrocomissioning and lighting alterations show the most promise.

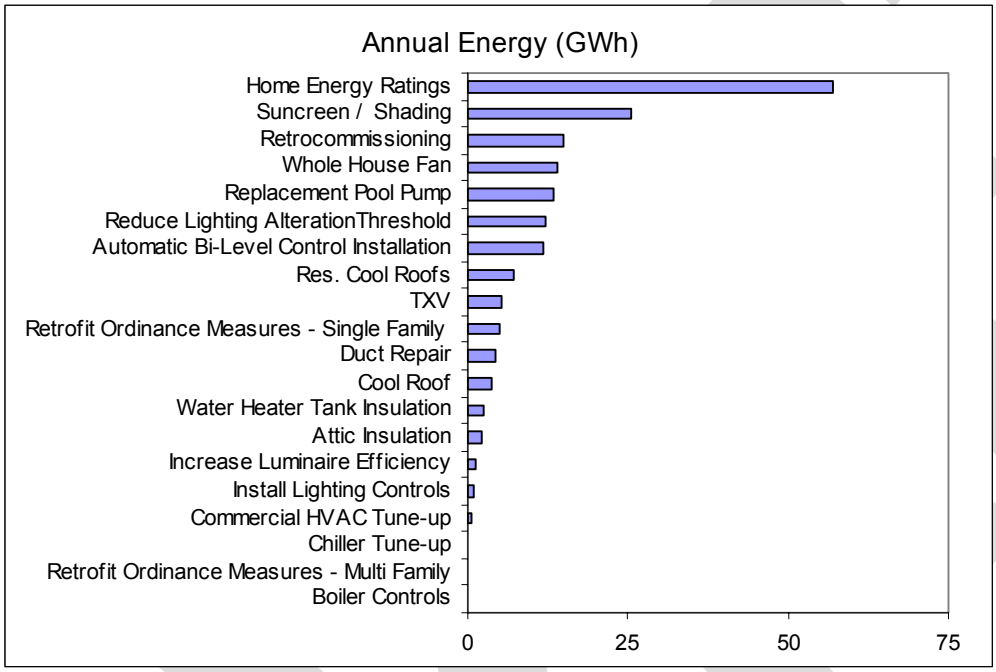


Figure 6: Estimated Annual Energy Savings

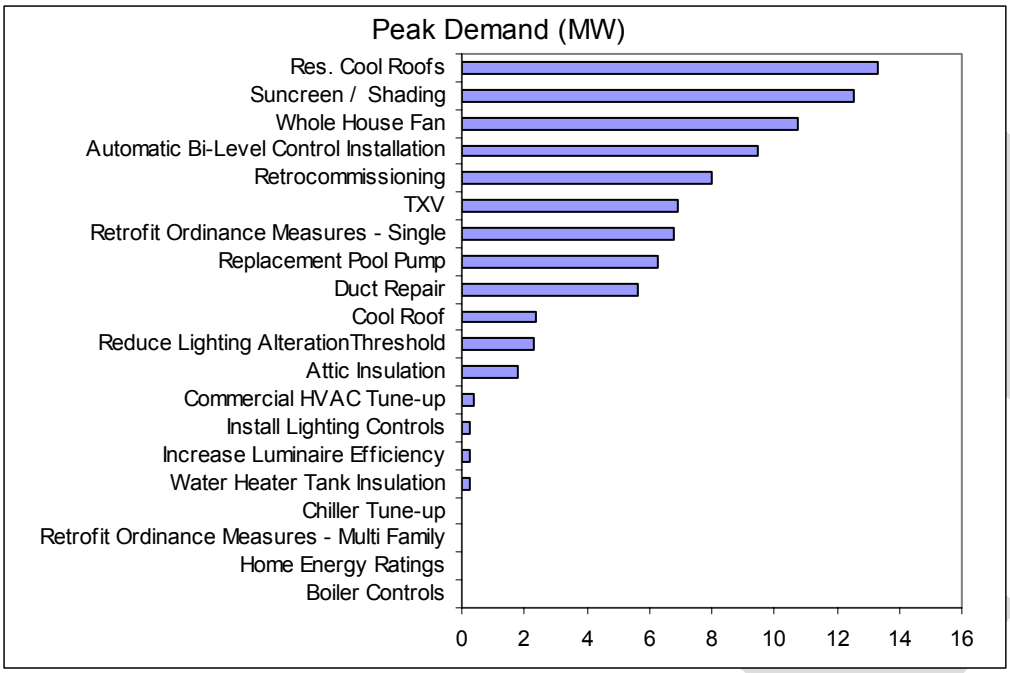


Figure 7: Estimated Annual Demand Savings

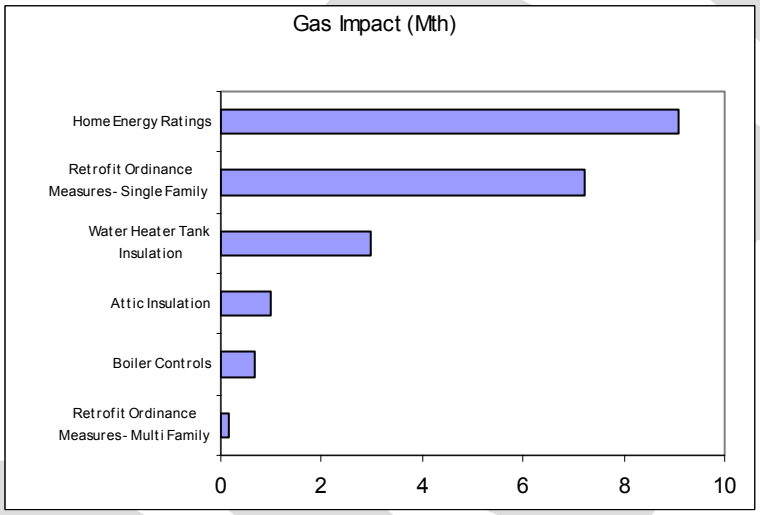


Figure 8: Estimated Annual Gas Savings

3.1 Expand and Enhance Building and Appliance Standards Regulations

The most straightforward path to increasing energy efficiency requirements in existing buildings is through existing regulatory mechanisms. The Title 24, Part 6 Building Energy Efficiency Standards impact the existing building market through alteration requirements. The Title 20 Appliance Efficiency Standards impact the existing building market through minimum performance requirements for appliances and space conditioning equipment sold or offered for sale in

California. New measures can be relatively quickly adopted through an established process that utilizes standardized cost effectiveness criteria, review and acceptance through a stakeholder review process.

The following code changes could be considered during a future Building Standards update.

3.1.1 Lowering the threshold for nonresidential lighting alterations

Recommendation

We recommend that the Title 24 Building Energy Efficiency Standards require lighting systems to meet the lighting power density requirements when 30% of the fixtures are being replaced during alteration (as opposed to the current 50% criteria). This would increase the number of lighting alterations that would be captured under the current "alterations" category, and would therefore be required to comply with the lighting power densities required for new construction. The enforcement mechanism would be local building department permitting and enforcement process. The typical payback period for lighting improvements is 6 months to 3 years, depending on the occupancy type, the age and efficacy of the equipment removed and the actual LPD and control systems installed.

Estimated Savings

Estimated energy savings and demand reduction were calculated using the methodology from the Impact Analysis, 2005 Update to the California Energy Efficiency Standards for Residential and Nonresidential Buildings completed by Eley Associates for the California Energy Commission. The report analyzes the potential impact of the 2005 Building Standards based on each revision to the code. The manner in which the standards "capture" lighting systems alterations to existing buildings does not change between 2001 and 2005, even though the standards are more stringent. To determine the difference between the 2001 and 2005 standards, the average first-year energy savings was calculated based on the weighted average of the 984 buildings in the NRNC database, the CEC estimation of the nonresidential building stock, and a churn rate of lighting systems in these buildings.

The energy and demand savings impact of our proposed measure is the difference between the 50% threshold and the 30% threshold. This was determined by utilizing the average first-year energy savings from the 2001 standard to the 2005 standard of 0.53 kWh/ft² and a demand reduction of 0.10 W/ft². The CEC estimates that the nonresidential building stock in California is 5.7 billion ft². We assume that lighting systems in these buildings will be more frequently replaced with energy efficiency lighting due to the lower threshold. This is referred to as the "Churn Rate." This results in 12.1 GWh of statewide first-year electricity savings and 2.3 MW of statewide first-year demand reduction. The estimate is summarized in Figure 9.

	Current Criteria	Proposed Criteria	Savings	Percent Reduction
Annual Energy (GWh)	151.1	163.1	12.1	8.0%
Peak Demand (MW)	28.5	30.8	2.3	8.0%
Assumptions:				
Savings from 2001 to 2005	0.53 (kWh/ft^2-y)	0.1 (W/ft^2)	Impact Analysis for 2005 Update	
Existing Stock	5,700,240,000	5,700,240,000	CEC estimate	
Churn Rate (each year)	5.0%	5.4%	Lighting systems replaced every 20 years	
Stock Affected Each Year	285,012,000	307,812,960	Existing Stock times Churn Rate	

Source: Impact Analysis, 2005 Update to the California Energy Efficiency Standards for Residential and Nonresidential Buildings, Eley Associates

Figure 9: Estimated Energy Savings for 30% Threshold for Nonresidential Lighting Alterations

3.1.2 Requiring automatic bi-level lighting controls for alterations, where appropriate

Recommendation

This suggestion is based on the work done for the 2005 Standards. In certain space types, automated bi-level controls can be installed to generate savings through reduced usage, when lights are not needed or spaces are intermittently occupied. These control savings are currently offered as power adjustment factors for new construction and alterations. However, requirements for building alterations are technically feasible and easily implemented.

Estimated Savings

Estimated energy savings and demand reduction were calculated using the methodology from the PG&E CASE Report for Bi-Level Lighting Control Credits, building data from the California Energy Commission 2003 Forecast Data for Nonresidential Buildings, and lighting controls saturation per the Non-Residential New Construction (NRNC) Database[2]. The savings are shown in the figure below.

[2] 1999 Nonresidential New Construction Baseline Study for the California Energy Commission and 1999-2002 Building Energy Assessment (BEA) Study for Southern California Edison. RLW Analytics

Assumptions				
Eligible Building Types	Office	Warehouse	Hotel/Motel	
Existing Building Stock (ft^2)	1,381,040,000	807,474,000	269,035,000	CEC estimate
Saturation of Controls	17%	2%	0%	NRNC database
Eligible Space Types	Small Private Offices	Warehouse Stacks	Hallways in Hotel/Motel	
% of Total Bldg Area Applicable	25%	80%	20%	PG&E CASE report
Stock Affected Each Year	14,477,027	31,587,625	2,690,350	
Churn Rate	5%	5%	5%	Lighting systems replaced every 20 years
LPD Controlls ($watts/ft^2$)	0.60	0.30	0.30	
Total Controlled Wattage	8,686,216	9,476,287	807,105	
Statewide Impact				
Eligible Space Types	Small Private Offices	Warehouse Stacks	Hallways in Hotel/Motel	Total
Electricity Savings (GWh)	4.40	5.54	1.76	11.71
Demand Savings (MW)	4.34	4.74	0.40	9.48

Figure 10: Estimated Energy Savings for Nonresidential Lighting Alterations Bi-level Controls

3.1.3 Expanding the requirements for nonresidential cool roofs

Recommendation

Requirements could be expanded to sloped roofs for nonresidential roof replacement. This is a logical extension of the requirements and authority within the existing Standards.

Estimated Savings

Estimated energy savings and demand reduction was calculated using the methodology from the Impact Analysis, 2005 Update to the California Energy Efficiency Standards for Residential and Nonresidential Buildings completed by Eley Associates for the California Energy Commission. Since sloped roofs represent 20% of the population, the impact of our proposed measure was determined by taking 25% of the savings estimated in the Statewide Impact Analysis. This results in 3.7 GWh of statewide first-year electricity savings and 2.4 MW of statewide demand reduction. The estimate is summarized in Figure 11.

Assumptions	
Existing Building Stock (ft^2)	5,700,310,000
Frequency of Roof Replacement (years)	15
Sloped Roof Saturation	20%
Statewide Impact	
Electricity Savings (GWh)	3.7
Demand Savings (MW)	2.4
Gas Impact (therms)	-50,866

Source: Impact Analysis, 2005 Update to the California Energy Efficiency Standards for Residential and Nonresidential Buildings, Eley Associates

Figure 11: Estimated Energy Savings for Nonresidential Cool Roofs for Sloped Roofs

3.1.4 Creating requirements for residential cool roofs

Recommendation

Requirements similar to cool roofs for nonresidential buildings could be expanded for residential roof replacements. This is a logical extension of the requirements and authority within the existing Standards. Current standards provide a credit to the building energy budget when cool roofs are specified.

Estimated Savings

Estimated energy savings and demand reduction was determined by finding the difference between 1982 base case residence with a cool roof versus a 1982 base case residence with a standard roof using MICROPAS energy modeling and Title 24 compliance software. The space cooling savings was determined in a variety of climate zones to come up with the Statewide average (9.9%). This was multiplied by the statewide residential usage for space cooling[3] ,the statewide saturation of air conditioning (38%), and the churn rate for residential roof replacement (20 years) This results in 7.1 GWh of statewide first-year electricity savings, and 13.3 MW of demand reduction. The estimate is summarized in Figure 12.

Assumptions	Annual Energy (GWh)	Peak Demand (MW)
Total Residential Usage for Space Heating	3234	0
Total Residential Usage for Space Cooling	3772	7065
Churn Rate	5%	Roof replacement occurs every 20 years
Average % Savings from Space Heating	0.0%	Based on Micropas analysis
Average % Savings from Space Cooling	9.9%	
Statewide Impact		
Annual Energy (GWh)	7.1	38% statewide AC saturation
Peak Demand (MW)	13.3	

Figure 12: Estimated Savings for Residential Cool Roof Alterations

3.1.5 Controls for Boiler Replacements

Recommendation

When the building energy efficiency standards were modified to include testing and sealing of duct systems upon HVAC replacement (2005 update) the logic behind it was that the authority evoked was for the entire system (HVAC indoor and outdoor units and duct systems), not just one component of the system. Therefore the standards look upon ducts as part of the HVAC system replacement and so all components are regulated at the time of replacement. The same logic can be applied to boilers and their ancillary systems. When boilers are replaced, or burners within boilers are replaced, a control system should be required to make the entire system run at optimum efficiency.

[3] California Statewide Residential Sector Energy Efficiency Potential Study, KEMA-Xenergy, Inc

Estimated Savings

Estimated energy savings were calculated based on the technical energy potential for boiler controls in multifamily buildings determined in the *California Statewide Residential Sector Energy Efficiency Potential Study*, prepared by KEMA-Xenergy, Inc. for PG&E and the California IOUs. The equation from that study was used the same way it was used for the other individual measure savings estimates. The equation can be found in section 3.4.

The statewide technical potential for boiler controls in multifamily buildings is 9,380,245 therms. Using the estimated service life of fifteen years, the churn rate for boiler alteration is considered to be 7%. The results are summarized in Figure 13.

Assumptions	
Churn Rate	7%
Technical Potential Therms	9,380,245
Statewide Impact	
Natural Gas Savings (therms)	683,564

Source: California Statewide Residential Sector Energy Efficiency Potential Study, KEMA-Xenergy, Inc

Figure 13: Estimated Natural Gas Savings for Boiler Controls in Multifamily Alterations

3.2 Residential Energy Conservation Ordinances

Some of the more progressive local governments are beginning to look at energy efficiency and its effect on the community. One of the ways communities are addressing energy efficiency is by evaluating the use of resale ordinances as a means to improve the efficiency of the community overall and improve the building stock within that community. Although a statewide requirement for evaluation and installation of certain measures and devices might be politically difficult in the shorter term for a statewide effort, locally it is possible where there is local grassroots support. Locally adopted ordinances could serve as a proving ground for an eventual statewide retrofit mandate.

Estimated Savings

Estimated energy savings were calculated by identifying the most common measures required from local ordinances and then creating a MICROPAS model to predict the energy (and demand) savings. The base-case model, the Building Industries Association (BIA)-created “medium house”, was run in representative climate zones across the state and the savings were pro-rated by relative density of older building stock.

The most common measures for single family residences include: Attic insulation, weatherstripping, water heater blanket, duct insulation, pipe insulation and low-flow showerheads.

The annual statewide savings estimate was created by applying the savings percentage to the fraction of the building stock affected by the requirement. The requirement to retrofit would only apply to residences that were at least 20 years old. These are the residences that are most likely to need the basic measures listed above. It is also assumed that through these efforts, the state will realize a 15% increase in the number of residences sold that would fall under requirements of locally adopted ordinances.

Measure	Statewide Energy Use (GWh/Yr)	Predicted Cooling Savings %	Appliance Saturation Percentage %	Communities expected to adopt ordinances %	Building Stock sold annually %	Statewide Savings (GWh/Yr)
Cooling Measures	3772.44	66.34%	38%	15%	3.40%	4.85
Total Electricity						4.85
	(Mth/Yr)	%				(Mth/Yr)
Heating Measures	1643.84	75.12%	100%	15%	3.40%	6.30
Water Heating Measures	1419.68	13.27%	97%	15%	3.40%	0.93
Total Gas						7.23

Assumptions:
Applies to all homes when sold that were built prior to 1982
Sources:
California Energy Demand 2003-2013 -Residential Electric Enduse Forecast, CEC
California Statewide Residential Sector Energy Efficiency Potential Study, 2003, KEMA - Xenergy Inc.
California Commerical Property Resale Data, Dataquick Information Systems

Figure 14: Energy Savings from Local Ordinances

In addition, some jurisdictions require boiler tune-up and controls for multifamily buildings with central boilers. To estimate those savings, a multifamily building model was created to predict the gas savings. The result was applied to the fraction of the multifamily market with central water heating.

Existing multifamily stock with central boilers was calculated as 31% of the total multifamily stock with 15% in Northern California and 40% in Southern California (Impact Analysis, Eley). We assumed that 65% of all multifamily construction is done in Southern California. As with retrocommissioning, we prorated the statewide savings for existing stock to savings for the number of pre-1992 homes sold in 2002.

The estimate is summarized in Figure 15.

Measure	Statewide Energy Use (Mth/Yr)	Predicted Water Heating Savings %	Appliance Saturation Percentage	Communities expected to adopt ordinances	Building Stock sold annually	Statewide Savings (Mth/Yr)
Water Heating Measures - Central Boilers	407.36	30.53%	31%	15%	2.50%	0.15

Assumptions:	
Applies to all buildings when sold that were built prior to 1982	
Percentage multifamily units with central boilers (Impact Analysis, Eley)	0.31
Average size of a multifamily dwelling unit (CEC staff report)	977 sq.ft.
Sources:	
Impact Analysis, 2005 Update to the California Energy Efficiency Standards for Residential and Nonresidential Buildings, Eley Associates	
California Energy Demand 2003-2013 -Residential Electric Enduse Forecast, CEC	
California Statewide Residential Sector Energy Efficiency Potential Study, 2003, KEMA - Xenergy Inc.	
California Commerical Property Resale Data, Dataquick Information Systems	

Figure 15: Estimated Gas Savings from Local Ordinances.

3.3 Home Energy Rating Systems

The HERS rating infrastructure for new and existing homes is well established and ready to provide home energy ratings and cost effectiveness analysis services. The Energy Commission completed process of adopting regulation for HERS to perform Title 24 new construction verification for certain measures (e.g. tight ducts). However, regulations for existing buildings, (and for nonresidential new construction, if appropriate) must be drafted and adopted before any mandate can be implemented that requires HERS ratings on resale.

Recommendation

We recommend the Commission investigate a HERS rating requirement upon resale for homes greater than 20 years old. At this point the assumption is that the requirement will be for the rating only. It is assumed, however, that a percentage of home sellers or buyers will take advantage of the information presented by the HERS rating and will take action to upgrade some features in the home, especially since the HERS rating itself will automatically qualify them for an increased loan amount to pay for the repairs and/or upgrades. We did not evaluate home refinancing (where no sale of the home takes place) as a trigger event at this time.

The California Energy Commission must complete its residential HERS guidelines before a program of this type could be launched or further researched.

Estimated Savings

The estimated energy savings were calculated by determining likely upgrades from PG&E's Time of Sale Energy Renovation (TOSER) program, conducted in program year 1999. The national HERS Technical Guidelines and data from the HERS Inspections provided by EnergyCheckup for Southern California Gas

Company (SCGC), Southern California Edison (SCE) and Pacific Gas and Electric (PG&E) from 1999 to present were also reviewed and form a part of the base assumptions.

For the purposes of this estimate, we relied on the TOSER savings data, and applied participation and applicability fractions to their estimates. Savings estimates are therefore conservative. The total savings potential is 57.53 GWh and 9.1 million therms.

Feasibility

There is some resistance to requirements upon resale that would need to be addressed through discussions with the industry if this approach is to be successful. More information on this issue can be found in the next section.

Measure	Net Savings by Measure per Home		Pre-1992 Homes Sold (annually)	Homes expected to adopt HERS recommendations	Applicability Factor - Electricity	Applicability Factor - Gas	Savings for homes sold annually	
	KWH/YR	Therms/YR			%	%	GWH/YR	1000 Therms/YR
Ceiling Insulation	250	32.6			27.55%	35.65%	3.50	591
Wall Insulation	163	25.3			27.55%	35.65%	2.28	459
Floor Insulation	7	1.3			5.94%	78.95%	0.02	52
Windows - Double Pane	294	39.3			27.55%	N/A	4.12	
Sunscreens	229	N/A			27.55%	N/A	3.21	
Infiltration Control - Weatherization	430	58.5			27.55%	35.65%	6.02	1,060
Duct Loss Reduction - 50%	257	69.4			27.55%	27.55%	3.60	972
Upgraded Gas Furnace AFUE - 80%	N/A	105			N/A	78.95%	N/A	4,215
Replace Electric Furnace/Heat Pumps with			254,199	20%				
Gas Furnace	38	N/A			5.94%	N/A	0.11	
Upgraded A/C - SEER 10	645	N/A			27.55%	N/A	9.03	
Setback Thermostat	148	14.7			27.55%	35.65%	2.07	266
Whole House Fan	396	N/A			27.55%	N/A	5.55	
Water Heater - (conversions to gas)	145	31.3			8.49%	86.25%	0.63	1,372
Lighting Efficiency - CFLs(150-520 Watts)	342	N/A			99.90%	N/A	17.37	
Power Planner	44	N/A			N/A	N/A	N/A	
Low-Flow Devices	3	3.3			8.49%	86.25%	0.01	145
Total	3,391.00	380.70					57.53	9,132

Assumptions:		
Total pre-1982 Homes sold in 2002 (Dataquick)	254,199	21183.25
% Homes expected to adopt HERS recommendations (TOSER EEM	20%	
Sources:		
2000 Market Effects Study of the TOSER EEM Program - Updated Final Report, Xenergy Inc.		
California Commerical Property Resale Data, Dataquick Information Systems		

Figure 16: Estimated energy savings for HERS required energy efficiency improvements for single family homes

3.4 Individual Measures to Consider During Time of Sale

If authority were granted to the California Energy Commission, energy efficiency upgrade measures could be required at time of property transfer. Just as for the other measures suggested during this trigger event, a process would need to be developed in cooperation with the real estate industry to make this trigger event work.

A list of candidate measures was created by evaluating a variety of energy efficiency upgrades with a variety of feasibility criteria. The energy efficiency upgrades must:

1) be possible during time of sale
2) have significant savings potential

3) be relatively noninvasive, and
4) be cost effective at the particular trigger event.

The candidates measures applicable for time of sale include:

Residential	Nonresidential
Attic Insulation	Chiller Tune-up
Duct Repair	Commercial HVAC Tune-up
Replacement Pool Pump	Increase Luminaire Efficiency
Suncreen / Shading	Install Lighting Controls
TXV	
Water Heater Tank Insulation	
Whole House Fan	

Figure 17: Candidate Measures for Time of Sale Regulation

Estimated Savings

In order to estimate savings from candidate measures, we used the savings estimates from the Kema-Xenergy technical potential study and applied them to the frequency of the resale event. This study was used because it addresses naturally occurring events, applicability and feasibility.

The core equation used to calculate the energy technical potential for each individual efficiency measure in the technical potential study is determined by multiplying the total number of dwelling units, the base-case equipment UEC (unit energy consumption), the applicability factor, the not complete factor, the feasibility factor, and the savings factor where:

- The *total number of dwelling units* applies to the particular market segment of interest.
- *Base-case equipment UEC* is the energy used per dwelling by each base-case technology in each market segment. This is the consumption of the energy-using equipment that the efficient technology replaces or affects. For example, if the efficient measure were an efficient air conditioner, the base UEC would be the annual kWh per dwelling of an equivalent standard efficiency air conditioner.
- *Applicability factor* is the fraction of dwelling units that is applicable for the efficient technology in a given market segment, for the example above, the percentage dwellings with air conditioners.
- *Not complete factor* is the fraction of applicable dwelling units that has not yet been converted to the efficient measure; that is, (one minus the fraction of dwellings that already have the energy-efficiency measure installed).
- *Feasibility factor* is the fraction of the applicable dwelling units that is technically feasible for conversion to the efficient technology from an engineering perspective.

- Savings factor is the reduction in energy consumption resulting from application of the efficient technology.

The savings are summarized in the following table. These savings are estimated for each measure individually. The savings are not additive across measures because some efficiency upgrades reduce the potential savings of others when used in combination.

Type	Measure	Frequency of Event	Annual Energy (GWh)	Peak Demand (MW)	Gas Impact (therms)
Nonresidential	Chiller Tune-up	0.2%	0.03	0.05	
Nonresidential	Commercial HVAC Tune-up	0.2%	0.67	0.37	
Nonresidential	Increase Luminaire Efficiency	0.2%	1.32	0.28	
Nonresidential	Install Lighting Controls	0.2%	1.05	0.28	
Residential	Attic Insulation	3.4%	2.05	1.78	994727
Residential	Duct Repair	3.4%	4.50	5.66	0
Residential	Replacement Pool Pump	3.4%	35.35	6.29	
Residential	Suncreen Shading	3.4%	25.61	33.01	
Residential	TXV	3.4%	5.29	6.89	
Residential	Water Heater Tank Insulation	3.4%	2.60	0.26	2961532
Residential	Whole House Fan	3.4%	14.01	10.75	
Assumptions:					
Homes 20 years and older would be regulated at time of sale					
Sources:					
California Statewide Energy Efficiency Potential Study, 2003, KEMA - Xenergy Inc.					
Commercial Forecast Data, CEC					
California Commerical Property Resale Data, Dataquick Information Systems					

Figure 18: Savings Potential from Individual Measures upon Resale

The residential pool pump reveals a huge opportunity because the newer motors use about half the energy and there are still many motors still operational. The sunscreen shading estimate also looks high and, although it reflects the numbers in the Kema-Xenergy report, it needs to be further scrutinized before the number can be fully trusted. Duct repair and TXV have high savings potential, just as they do in the new construction market.

3.5 Retrocommissioning for Large Office Buildings

Retrocommissioning refers to the process of "commissioning" an existing building by taking an extensive look at the whole-building *systems* performance. It is designed to insure that a building performs as energy efficiently and cost effectively as possible while meets the owner's operational needs with the building equipment currently installed. The extent of energy savings depends on the pre-existing condition of the building's energy features and the comprehensiveness of the retrocommissioning.

The California Commissioning Collaborative is an ad-hoc group of government, utility and building services professionals whose purpose is to facilitate the

development of cost-effective programs, tools, techniques and a service delivery infrastructure that enables the implementation of the building commissioning process in newly constructed and existing buildings. This group and others could be part of a working group to assist in determining how and under what circumstances building commissioning or retrocommissioning would be practical and cost effective for a statewide mandate.

Recommendation

We recommend that the Commission explore expanding their authority to require large office buildings that are at least 10 years old to be retrocommissioned at time of sale. Large office buildings are those with 10,000 sq.ft. or more of floor space. A comprehensive retrocommissioning project should include documented process assessment, diagnostics and functional testing and recommendations for implementation of improvements for the following items.

- HVAC equipment
- Sensors (ie: occupancy sensors, chilled and hot water temperature sensors)
- Energy management systems
- Economizers and/or variable speed drives
- Missing equipment

In addition, the retrocommissioning industry is in need of quality assurance review and certification procedures. The CEC can play an important role in defining and facilitating these responsibilities.

Estimated Savings

Energy savings potential for retrocommissioning large office spaces was estimated from past and current efforts to promote retrocommissioning, as documented in “Retrocommissioning: Program Strategies to Capture Energy Savings in Existing Buildings”, completed by Jennifer Thorne and Steven Nadel. The report estimated the energy savings potential as 5 to 15% of the total energy consumed. For our calculations we assumed the savings potential as 10% of the total energy consumed by the building.

To estimate savings we multiplied the pre-1992 large office building stock sold in 2002 times the energy use for that occupancy type and the savings factor. The estimates reveal peak savings of 8 MW and energy savings of 15 GWh annually. The savings are shown in the figure below:

Total Area pre1992	Total Energy Consumed	Pre 1992 Large Office Area sold (annually)	Energy Savings Potential	Energy saved	Ratio Energy Savings / Peak Savings	Peak Savings
SqFt	GWh/YR	SqFt	%	GWh/YR	KWh/KW	MW
926,758,000	14036	9,824,041	10%	15	1950	8

Assumptions:	
% Energy Savings: (Median is 19%. Range is 5 to 15%)	10%
Savings calculated for large office buildings sold per year (2002) that are at least 10 years old	
Pre-1992 Large Office Area Sold as a percentage of Total Commerical Area Sold	18.36%
Ratio of total energy savings to peak energy savings.	1950 KWh/KW

Sources:
Retrocommissioning: 2003 Program Strategies to Capture Energy Savings in Existing Buildings, Jennifer Thorne and Steve Nadel, ACEEE.
Commercial Forecast Data, CEC
California Commerical Property Resale Data, Dataquick Information Systems

Figure 19: Estimated Savings from Retrocomissioning Large Office Buildings on Resale

4. RECOMMENDATIONS SUMMARY AND NEXT STEPS

The current mechanisms, the Title 24, Part 6 Building Energy Efficiency Standards and the Title 20 Appliance Efficiency Standards, effectively change the market for building energy efficiency measures. The standards update process must continue to track and keep pace with the technological and process improvements of the industry. Greater energy efficiency continues to be captured with each standard revision cycle.

In order to establish new authority to regulate buildings at the time of sale or transfer of title, more research is necessary, including:

- Completion of HERS regulations for existing buildings
- Formation of Working Groups to resolve issues surrounding regulation at resale
- Formation of Working Groups around specific technical issues, namely HERS ratings, retrocomissioning and coordination of content and implementation of locally developed ordinances.

The working groups, made up of members from key stakeholder groups, can outline and address the technical and political issues associated with a specific proposal. They could identify and organize necessary research and analysis to determine the appropriate applicability parameters including: age of building or system, occupancy group, climate zone, product availability and reliability, cost, appropriate alternates to proposed requirements, inspections and other administrative variables that must be addressed. They could also investigate incentives for voluntary adoption and their eventual tie-in to codes and standards work. Focusing on these areas will best utilize available resources to capture maximum energy savings potential.

4.1 Second Tier Measures and Strategies

There are a number of promising strategies that warrant further research. These strategies are not mature enough to consider for the short term but as time and resources permit, they should be further explored.

The initial research performed on these strategies points to significant energy savings once technological and political hurdles are crossed. These include:

- Connecting energy savings to appraisal value, for both residential and commercial properties.
- Requiring or rewarding buildings incorporating demand responsive controls, including wireless controls and sensors.
- Creating a set of performance criteria for controls, to improve their acceptance in the marketplace.

- Considering more changes to the appliance standards, including: increasing the efficiency of pool pump motors, regulating landscape lighting and refining the appliance efficiency requirements for residential load shedding thermostats.
- Encouraging regular, routine maintenance on commercial buildings. This could circumvent a number of problems, particularly with economizer reliability. Recent research show that only 30% of installed economizers are functioning appropriately. Technicians would need to be trained to focus on techniques that promote energy conservation and increase system performance.

4.2 Conclusions

There is vast potential for energy and demand savings in the existing buildings market, for both residential and commercial buildings and across all occupancy types. While trigger events such as replacement, alteration or equipment repair offer opportunities for efficiency improvement, other regulations, such as mandatory requirements or rating upon building transfer could offer additional opportunities and warrant further research. It is recommended that additional resources be focused on the specific measures identified in this report. In this way, progress can be made towards implementing the most promising strategies, whether by voluntary or regulatory means.

5. APPENDIX A – BACKGROUND DATA AND RESEARCH EXCERPTED FROM PRIOR REPORTS

5.1 Characteristics of the Existing Building Market

5.1.1 Residential Sector

To assess the energy savings potential in the residential sector, the details of the current and historic building stock and market must be understood. In this section, we present:

- Types of residences and their share of the market
- Ages of residences and their share of the market
- Frequency of residential real estate transactions
- Average household energy expenditures

Types of Residences

Tables 1 and 2 detail the types of residential buildings in California and total number of dwelling units those buildings represent. Unit type in Table 1 is based on ownership and building type. The majority are single-family units occupied by the owner. In Table 2, the number of units is based on structure. Single-family units dominate the market.

Type and Ownership of Housing Units in California, Million of Households

	Total Units
Single-Family Detached	6.5
Single-Family Attached	1.3
Multi-Family (2-4 units)	0.5
Multi-Family (5 or more units)	2.7
Mobile Home	0.5
Total Housing Units	**11.5**

* U.S. Dept. Of Energy, Energy Information Administration, Housing Characteristics 1997

Table 1: Type of Housing Units

Types of Housing Units in California, Based on Structure		
	Total Units	% of Total
1-unit, detached	6,883,493	56.4%
1-unit, attached	931,873	7.6%
2 units	327,024	2.7%
3 to 4 units	697,779	5.7%
5 to 9 units	722,827	5.9%
10 to 19 units	619,092	5.1%
20 or more units	1,462,793	12.0%
Mobile home	538,423	4.4%
Boat, RV, van, etc	31,245	0.3%
Total Housing Units	**12,214,549**	**100%**

* U.S. Bureau of the Census, Census 2000

Table 2: Types of Housing Units, Based on Structure

Table 3 lists the housing tenure of occupied housing units. The majority of homes in California are owner-occupied (56.9%). The renter-occupied market presents unique issues such as split benefits to occupant/owner and must be looked at differently. Even though they're not the majority, renter occupied units constitute a significant portion of the market.

Housing Occupancy in California		
	Number	% of Total
Owner-occupied housing units	6,546,334	56.9%
Renter-occupied housing units	4,956,536	43.1%
Total occupied housing units	**11,502,870**	**100%**

* U.S. Bureau of the Census, Census 2000

Table 3: Number of Residential Units Owned Versus Rented

Age of Residences

In Table 4, we examine the housing stock based on when the unit was built. Residences were grouped into four timeframes:

- Units built prior to 1982
- Units built between 1982 and 1991
- Units built between 1992 and 2000
- Units built after 2000

These timeframes were based on major stringency increases of the Building Energy Efficiency Standards for residential buildings. Before 1982, there were very few residential energy requirements. The years 1982, 1992, and 2001 represented major stringency increases in the Standards, leading to more energy efficient units built during those years. Table 4 shows that the majority of

buildings, regardless of type, were built prior to 1982. The prevalence of older buildings is further illustrated in Figure 20 for single-family homes.

Residential Building Stock

	Single-Family Dwelling Units		Multifamily Buildings	
	Units Added	Total Units	Units Added	Total Units
pre-1982		5,554,290		2,723,422
1982-1991	1,080,354	6,634,644	610,900	3,334,322
1992-2000	720,714	7,355,358	216,720	3,551,042
2001-current	193,220	7,548,578	73,577	3,624,619

Source: California Energy Commission, 2003 Forecast Data for Residential Buildings.

Table 4: Residential Building Stock in California

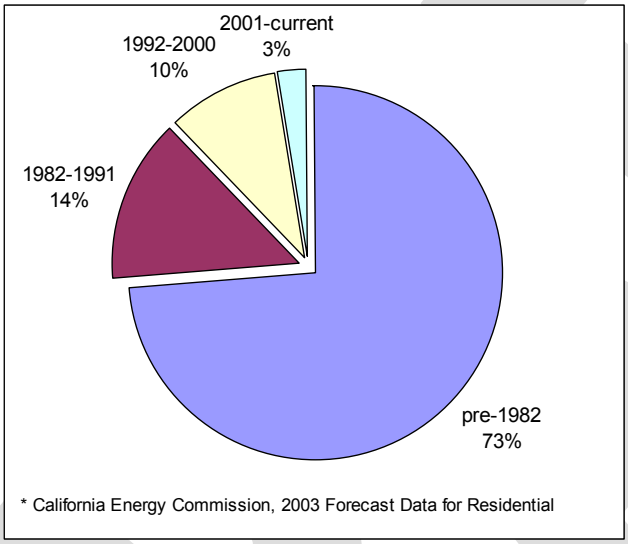


Figure 20: Percentage of Single-Family Dwelling Units Built in California by Vintage

As homes age, features within a home are upgraded, appliances are replaced and remodels are planned and built. These events impact the efficiency of a home. We will discuss the impact of these events further in Section 3.

Residential Resale Market

Table 5 shows the number of dwelling units sold and the total floor area those sales represent. The data is shown by time groupings that correspond with standards efficiency stringency levels. Similar to the building stock, the residential resale market is dominated by homes built prior to 1982. These pre-1982 homes were built before any significant strides were made in residential energy standards. Figure 21 shows that the percentage of older homes in the resale market remained relatively constant. It also shows that the volume of turnover in the residential market is significant. .

Residential Building Resales from 1993-2002

Single-Family Dwelling Units

Year Built	Number of Units	Total Area (10^6 Sq.Ft.)
pre-1982	2,181,865	3,312.8
1982-1991	573,497	1,103.1
1992-2000	210,012	433.5
2001-current	1,871	4.9
Total	2,967,245	4,854.3

Multifamily Dwelling Units

Year Built	Number of Units	Total Area (10^6 Sq.Ft.)
pre-1982	181,348	756.5
1982-1991	12,853	144.9
1992-2000	3,274	13.4
2001-current	37	0.1
Total	197,512	914.8

Condominiums

Year Built	Number of Units	Total Area (10^6 Sq.Ft.)
pre-1982	345,648	416.1
1982-1991	254,137	329.7
1992-2000	49,658	71.0
2001-current	420	0.7
Total	649,863	817.4

* Source: California Residential Property Resale Data 1993-2002, DataQuick Information Systems

Table 5: Residential Resales in California from 1993 -2002

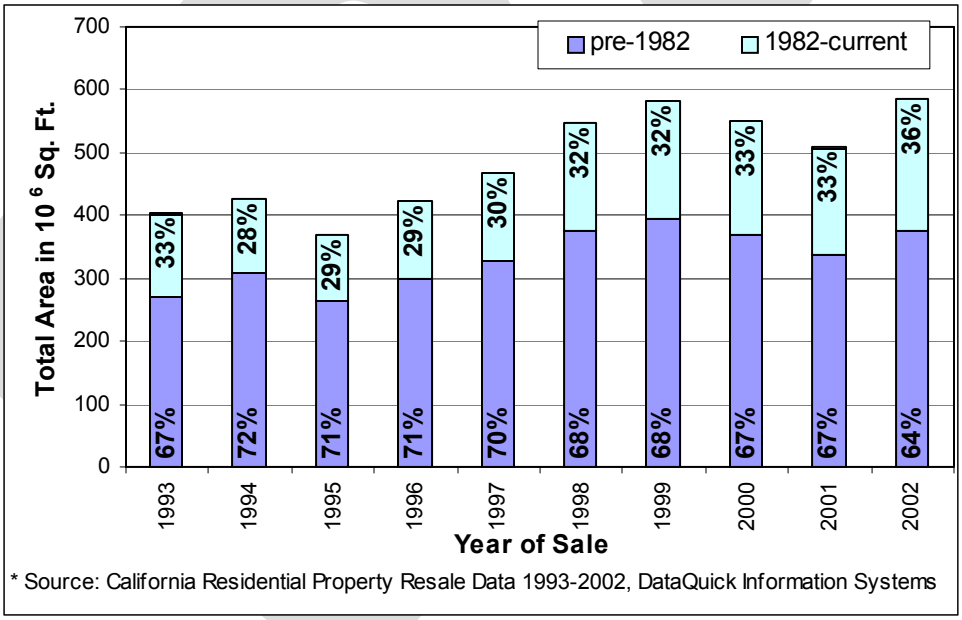


Figure 21: Single-Family Dwelling Resale Area By Year in California

Figure 22 looks at the resale data from the past ten years to determine the trend of building size. Single-family dwelling units have increased in area since 1982.

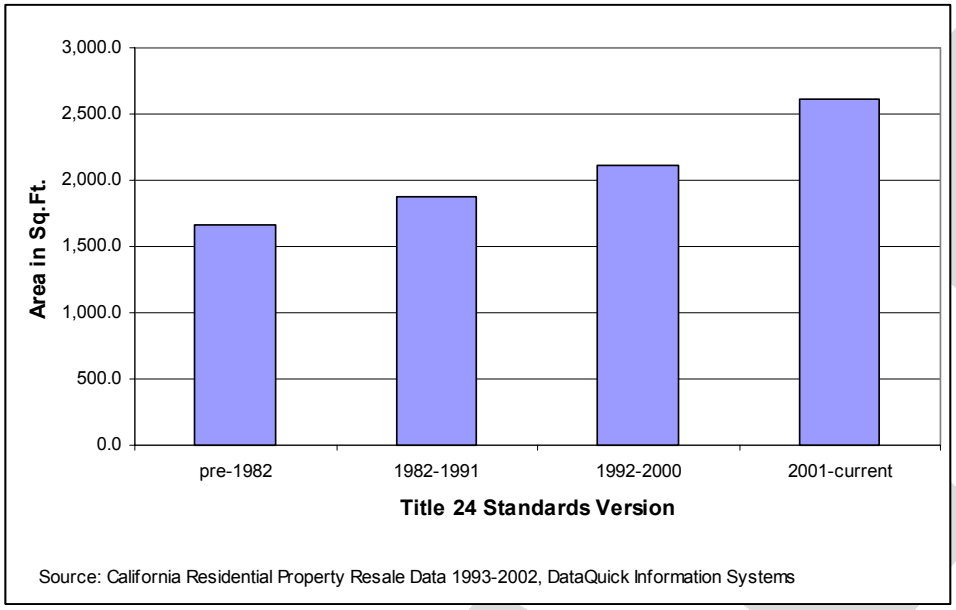


Figure 22: Increase in Average Area of California Residential Buildings

The frequency of real estate transactions is another important consideration for the potential trigger of a home sale as an opportunity for energy efficiency improvements. The high frequency of occupants changing residences is further shown in Table 6. The 2000 U.S. census revealed that more than half of the respondents (53%) had moved into their present unit within the past five years.

Year Householder Moved Into Unit For California

	Number of Households	% of Total
1 year ago	2,456,426	21.4%
2 to 5 years ago	3,630,521	31.6%
6 to 10 years ago	1,842,387	16.0%
11 to 20 years ago	1,752,425	15.2%
21 to 30 years ago	1,023,528	8.9%
Over 30 years ago	797,583	6.9%
Occupied Housing Units	**11,502,870**	**100%**

* U.S. Bureau of the Census, Census 2000

Table 6: Year California Householders Moved into Present Unit

Residential Energy Usage

In 1997, the average California household spent $1009 on energy.[4] Table 7 shows the average national household energy expenditure by age of home,

[4] U.S. Dept. Of Energy, Energy Information Administration, Residential Energy Consumption Survey 1997

shown in five-year increments. Older buildings typically carry a higher energy cost per square foot. However, older homes are significantly smaller than today's homes, and most new homes have a larger saturation of appliances so the per household cost for energy of homes has not changed significantly by vintage.

1997 Household Energy Expenditures, by Vintage ($ per Sq. Ft)

Year	Per Household	Per Square Foot
Prior to 1980	$ 1,408	$ 0.88
1980 to 1986	$ 1,312	$ 0.80
1987 to 1989	$ 1,491	$ 0.77
1990 to 1995	$ 1,453	$ 0.70
1996 to 1997	$ 1,324	$ 0.62
Average	$ 1,403	$ 0.82

2002 Bldgs Energy Databook, US DOE Office of Energy Efficiency and Renewable Energy

Table 7: National Average Household Energy Expenditures Valuated in Dollars per Sq. Ft.

Table 8 shows who pays the energy bills in rental properties. Occupants are overwhelmingly the primary party responsible for energy costs. Where landlords are responsible for the utility bill, there is more incentive to make improvements to the building since they will directly benefit from any reduction in energy costs. In the case where the tenant pays the utility bills, the owner will have less incentive for making improvements to the building. If the tenant makes the improvement, assuming they can obtain permission to alter the building, they will not benefit from any increase in equity. Furthermore, it is uncertain that the tenant will remain in the building long enough to recoup the cost of their investment through the energy savings. This split incentive is a barrier to energy efficiency improvements in rental property.

Party Responsible for Electricity and Gas Among Rented Occupied Units

	Landlord	Occupant	Don't Know	Sample Size
Electricity Costs	3%	97%	0%	494
Gas Costs	11%	88%	1%	456

* RLW Analytics, Inc. California Statewide Lighting and Appliance Saturation Study Final Report. 2000

Table 8: Who Pays Electric and Gas Costs in California's Residential Rental Units

5.2 Commercial Sector

To assess the energy savings potential in the commercial sector, we researched the current and historic building stock and market. This section presents:

- Types of commercial buildings and their share of the market
- Ages of commercial buildings and their share of the market
- Frequency of commercial real estate transactions
- Ownership characteristics of buildings

Types of Commercial Buildings

The commercial sector is often divided by occupancy type. Figure 23 provides the percentage of each occupancy type relative to the total nonresidential floor area. The largest occupancy types by floor area are large offices (17%), retail (16%), and non-refrigerated warehouses (13%). The other category listed in Figure 23 consists of occupancy types where each type is less than 1% of the total floor area for all commercial buildings.

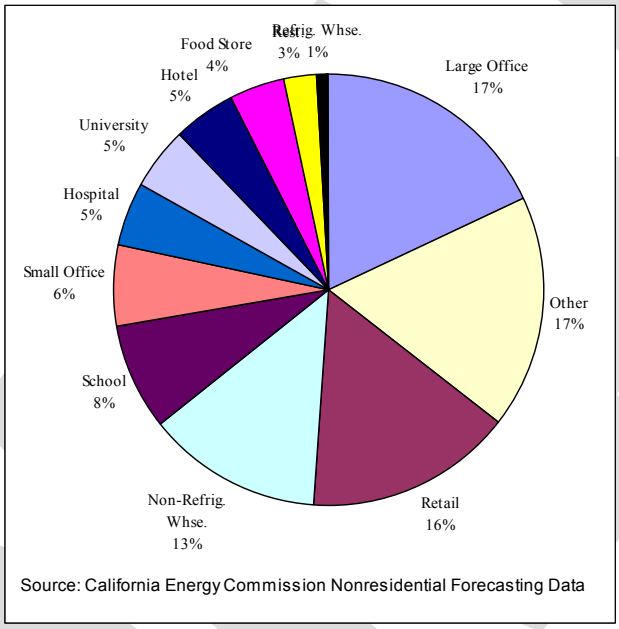


Figure 23: Percent of 2002 California Nonresidential Floor Area by Occupancy Type

Table 9 provides the average floor area for nonresidential buildings by occupancy type. The occupancy types are slightly different than described in the building stock, but provide similar results as Figure 23.

Average Floor Area of Nonresidential Buildings By Occupancy Type

Bldg Type	Average SqFt
C&I Storage	227,619
General C&I Work	82,435
Office	78,165
Retail and Wholesale Store	70,313
Medical/Clinical	68,282
Theater	62,843
Fire/Police/Jails	49,852
Grocery Store	49,758
School	42,946
Libraries	38,234
Community Center	35,992
Other	34,704
Gymnasium	32,716
Religious Worship, Auditorium, Convention	25,065
Hotels/Motels	17,667
Restaurant	11,529

Source: 1999 Nonresidential New Construction Baseline Study for the California Energy Commission and 1999-2002 Building Energy Assessment (BEA) Study for Southern California Edison. RLW Analytics

Table 9: Average Floor Area of California Nonresidential Buildings by Occupancy Type

Age of Commercial Buildings

In this section, we examine the commercial floor stock area based on when the unit was built. Buildings were grouped into four timeframes:

- Units built prior to 1978
- Units built between 1978 and 1991
- Units built between 1992 and 2000
- Units built after 2000

These timeframes were based on major stringency increases in the Building Energy Efficiency Standards for commercial buildings. The Building Energy Efficiency Standards was established in 1978 in response to a legislative mandate to reduce California's energy consumption. The years 1978, 1992 and 2001 represented major stringency increases in the nonresidential Standards. Figure 24 illustrates the portion of building floor space constructed during each timeframe as a percentage of all nonresidential building stock that existed in 2002. The predominant category is floor space built prior to 1978.

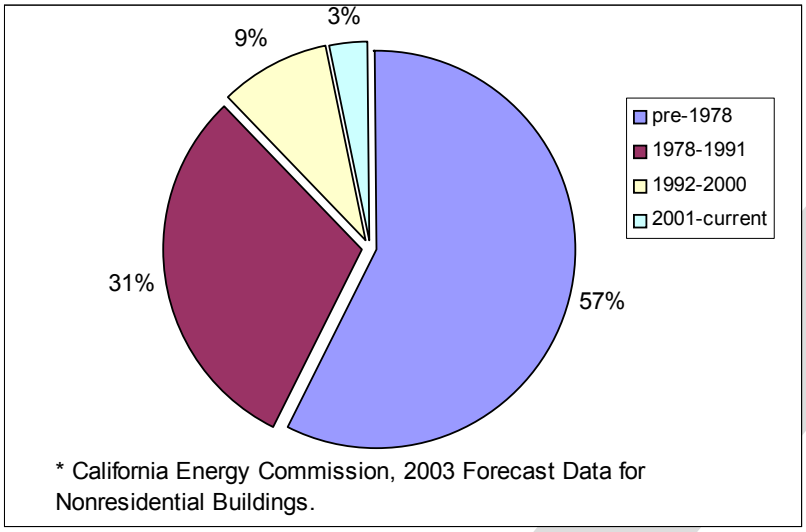


Figure 24: Breakdown of 2002 California Nonresidential Floor Stock Areas

In Table 10 and Table 11, nonresidential floor stock area is shown by occupancy type and vintage. For all occupancy types, buildings built prior to 1978 constitute more than half of the current building stock. For educational buildings (school and university), two-thirds of the current building stock was built prior to 1978.

Nonresidential Floor Stock Area in 10^6 Sq.Ft.													
Year	Small Office	Restaurant	Retail	Food Store	Non-Refrigerated Warehouse	Refrigerated Warehouse	Schools	University	Hospital	Hotel	Other	Large Office	Total
pre-1978	181	91	500	135	368	23	357	198	150	139	597	512	3,251
1978-1991	136	42	277	68	287	12	40	45	84	108	271	415	1,784
1992-2000	158	55	373	92	364	20	84	71	123	120	378	487	2,326
2001-current	167	59	398	98	394	22	96	79	131	130	410	522	2,505

* California Energy Commission, 2003 Forecast Data for Nonresidential Buildings.

Table 10: Nonresidential Floor Stock Area by Occupancy Type

Percent of Nonresidential Floor Stock Area (10^6Sq.Ft.) Built Prior to 1978

Year	pre-1978	Current Stock	% of Stock
Small Office	191.4	347.7	55%
Restaurant	94.3	149.5	63%
Retail	519.8	897.5	58%
Food Store	140.3	233.4	60%
Non-Refrigerated Warehouse	383.2	762.3	50%
Refrigerated Warehouse	23.8	45.2	53%
School	361.4	453.0	80%
University	201.3	277.1	73%
Hospital	153.3	280.5	55%
Hotel	140.9	269.0	52%
Other	610.5	1,007.7	61%
Large Office	523.1	1,033.3	51%
Total	**3,343.4**	**5,756.2**	**58%**

* California Energy Commission, 2003 Forecast Data for Nonresidential Buildings.

Table 11: Percent of California Nonresidential Floor Area Built Prior to 1978 By Occupancy Type

Commercial Resale Market

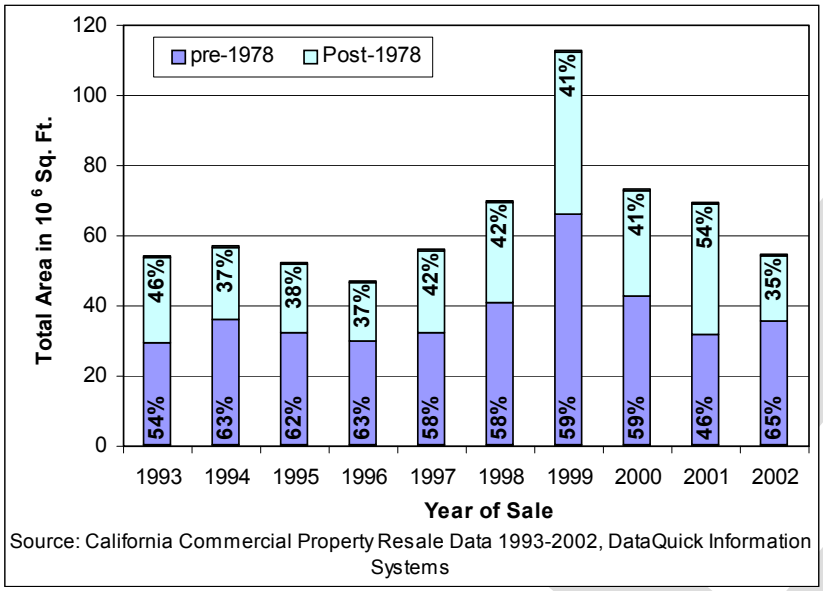
In Table 12, the total amount of floor space sold from 1993-2002 is shown. The data is displayed according to building vintage. Similar to the building stock, the nonresidential resale market is dominated by buildings constructed prior to 1978, before the nonresidential Building Energy Efficiency Standards were enacted. The prevalence of older commercial buildings involved in real estate transactions is further illustrated in Figure 25. In the past ten years, the majority of commercial building floor area sold in California was built prior to 1978. However, unlike the residential market, the percentage of older floor area in the resale market was more variable.

Commerical Resale Area in 10^6 Sq.Ft.

	1993-2002	% of Total
pre-1978	371.7	58%
1978-1991	236.8	37%
1992-2000	28.7	5%
2001-current	0.1	0%
Total	**637.4**	**1.0**

Source: California Commercial Property Resale Data 1993-2002, DataQuick Information Systems

Table 12: Commercial Floor Area Resold in California from 1993-2002



Source: California Commercial Property Resale Data 1993-2002, DataQuick Information Systems

Figure 25: Commercial Floor Area Resold in California by Year

Ownership Characteristics

Table 13 lists the ownership types of commercial buildings from the 1999 Commercial Buildings Energy Consumption Survey by the U.S. Dept. of Energy's Energy Information Administration. The majority of floor area is owner-occupied (56.1%).

Ownership Types of U.S. Commercial Floor Area

	Total Floorspace (10^6 Sq. Ft.)	% of Total
Publicly-owned	12,343	18.3%
Owner-occupied	37,785	56.1%
Nonowner-occupied	15,596	23.2%
Unoccupied	1,613	2.4%
Total floorspace	**67,337**	**100%**

* U.S. Dept. of Energy, Energy Information Administration, 1999 Commercial Buildings Energy Consumption Survey: Building Characteristics Tables

Table 13: Ownership Types of U.S. Commercial Floor Area

While the majority of commercial buildings are owned, many buildings are leased. Standard lease rates vary by occupancy types.[5] For office spaces, the standard lease is for a five-year period. For industrial space, the standard lease is for a ten-year period. Retail spaces have the shortest timeframe for a lease, typically three to five years.

[5] Conversation with Grubb & Ellis Research Department

5.3 Measures and their trigger events

5.3.1 Trigger Events Appropriate for Mandated Measures

The most promising trigger events are those where there is already an enforcement mechanism in place that would assist in the implementation of a new mandate. The Type 1 and Type 2 events are shown as bold in the table below meet those criteria.

Type 1 - Events that involve recording of title or a shift in primary occupants
Building Sale
Building Finance or Refinance
Building Lease, sublease or rental
Type 2 - Events that may require a building permit
Alteration
Addition
Equipment or building component replacement
Change in occupancy type (example: office to restaurant)
Change in status from unconditioned to conditioned
Type 3 - Events that trigger building component access
Repair
Commissioning or retrocommissioning
Scheduled maintenance
Type 4 - Events where site visits to the building are made
Inspection
Energy rating
Appraisal
EEM evaluation
Type 5 - Events where meter data is gathered or evaluated
Utility program participation
Account inquiry or rate change request

Figure 26: Trigger Events Appropriate for Mandated Measures

Sale of building already requires a series of inspections and the recording of legal documents pertinent to the specific property as discussed in Section 3. Although the CEC does not have regulatory authority in this area, such permission authority could be obtained from the legislature. In cities and counties, measures could be mandated through locally adopted ordinances.

Building refinance does not involve an ownership change and so provides an opportunity for the building owner to leverage additional funds to make energy efficiency improvements. A HERS rating could provide value here. With expanded authority, the HERS rating could be a requirement upon refinancing to the extent that is feasible with respect to federal and state law related to lending.

For multifamily or commercial buildings, the ***building lease, sublease or rental*** trigger event could provide an opportunity for mandates in specific cases. During this event, legal documents are exchanged between the owner and tenant and typically inspections are performed to document the condition of the building before the tenant takes occupancy.

Type 2 trigger events (***alteration, addition, equipment or component replacement change in occupancy and change in conditioned status***) are all events that often, with few limited exceptions, require a building permit. However, while additions almost always require a permit, alterations only necessitate a permit when required by local building departments. The permit process involves an application and inspection, which is designed to verify the equipment or building component, is installed according to code. Since the primary mechanism for the Building Energy Efficiency Standards is the building permit and inspection process, measures triggered by Type 2 events are, with a few limited exceptions, within the Energy Commission's existing authority. There are some logical applications of and extensions of that current authority that are described in the tables that follow.

Measures Suggested for Consideration

Individual prospective measures were selected based on proven energy savings from statewide utility incentive programs, program pilots, and building rating protocols developed by industry consensus. These measures are market ready, cost effective and technologically feasible. While different application scenarios would yield different energy savings and cost effectiveness results, all of the measures listed would merit further review and analysis.

How to Read the Measure Review Tables

The tables show candidate measures that could be mandated during the specific trigger event. The first column lists the measures, which are sorted by group. The second column, '"candidate measure" serves as an indicator if that measure might be suited to a mandate given certain conditions. The measures with an "X" in the candidate measure column warrant further review. Measures with no 'X' would be better suited to another trigger or for voluntary programs or processes. The specific conditions are listed in the comments column. In addition, the comment column provides clarification for cases where a measure is not appropriate. The tables are intended to spark further discussion, analysis and prioritization.

5.3.2 Measures Review for Single Family Buildings

Table 14 illustrates candidate measures that could be mandated during the alteration or other Type 2 trigger event. The alteration trigger event provides the longest and most promising set of potential measures. This is because there is a proven, existing working mechanism in place and time of alteration is the most logical time to consider related energy efficiency measures.

Possible Efficiency Measures at ALTERATION Trigger Event - Single Family Building

Measure	Candidate Measure	Comments
Integrated Measures		
HERS Rating		
HERS Rating and Building Upgrade		
HVAC		
Air Conditioning Plant Efficiency Upgrade		Appropriate when unit is performing poorly
Boiler or Furnace Upgrade		Appropriate when unit is performing poorly
Blower Fan Efficiency		More appropriate for appliance standard
Refrigerant Charge and Air Flow measurement		If unit is a candidate for retrofit and HVAC system is involved
Equipment "Right" sizing	X	If unit is being replaced as part of the alteration
System type change		not likely due to logistical problems
Install Evaporative Cooler or Pre-cooler		If unit is a candidate for retrofit and HVAC system is involved
Duct Insulation		Require "buried" ducts after sealing and testing
Duct Testing, Sealing, and Retesting		Already covered under alteration requirements
Ceiling Fan		
Whole House Fan		
Programmable Set Back Thermostat		Already covered under alteration requirements
Lighting		
Medium base socket CFLs	X	Must pass persistence hurdle
Pin-based CFLs		Currently covered if lighting system is involved
Maximize Daylighting	X	Upon roof replacement - 'offramp' should be provided
Install/Upgrade Lighting Controls	X	Difficult to mandate at this trigger because of personal preferences
Building Envelope		
Cool Roofs	X	Upon roof replacement only
Radiant Barrier	X	Upon roof replacement only
Roof / Attic Insulation	X	Existing levels must be at or below R19 typically
Floor Insulation		Access issues make first cost prohibitive
Air Infiltration Testing, Sealing, and Retesting		
Wall Insulation	X	Appropriate when wall is opened
Window U-factor		
Window SHGC		
Sunscreens	X	One of these three may be possible in hot climate zones upon air conditioner replacement or window replacement
Overhangs/exterior shading devices	X	
Integrated Landscape	X	
Water Heating		
Water Heater Energy Factor upgrade		Appropriate when unit is performing poorly
Tank Insulation		Currently Covered if EF is below .58
Pipe Insulation		Access problems may occur -- extension of lines covered
Appliances		
Low-Flow Showerheads / Faucets		Appliance Efficiency Standard Applies
Refrigerator		Appliance Efficiency Standard Applies
Efficient Washer & Dryer		Appliance Efficiency Standard Applies
Efficient Dishwasher		Appliance Efficiency Standard Applies
Pool Pump Motor		Planned for Appliance Efficiency Standards

Table 14: Single Family Measures for Alterations Events

In Table 15, a list of possible measures to be considered at time of sale is provided.

Intervention at time of sale is not under the Commission's current authority. If authority were expanded, time of sale is an excellent opportunity to evaluate and potentially upgrade the existing stock.

Possible Efficiency Measures at RESALE Trigger Event - Single Family Building

Measure	Candidate Measure	Comments
Integrated Measures		
HERS Rating	X	Best Candidates for this Trigger Event
HERS Rating and Building Upgrade	X	
HVAC		
Air Conditioning Plant Efficiency Upgrade		Appropriate when unit is performing poorly
Boiler or Furnace Upgrade		Appropriate when unit is performing poorly
Blower Fan Efficiency		More appropriate for appliance standard
Refrigerant Charge and Air Flow measurement	X	
Equipment "Right" sizing		
System type change		
Install Evaporative Cooler or Pre-cooler		
Duct Insulation		
Duct Testing, Sealing, and Retesting	X	
Ceiling Fan	X	
Whole House Fan	X	
Programmable Set Back Thermostat		
Lighting		
Increase efficiency of hardwired systems		
Medium base socket CFLs	X	Must pass persistence hurdle
Pin-based CFLs	X	Difficult to mandate at this trigger because of personal preferences
Maximize Daylighting		
Install/Upgrade Lighting Controls	X	Difficult to mandate at this trigger because of personal preferences
Building Envelope		
Cool Roofs		Upon roof replacement only
Radiant Barier		Upon roof replacement only
Roof / Attic Insulation	X	Existing levels must be at or below R19 typically
Floor Insulation		Access issues make first cost prohibitive
Air Infiltration Testing, Sealing, and Retesting		As part of HERS diagnostic
Wall Insulation		Appropriate when wall is opened
Window U-factor		
Window SHGC		
Sunscreens	X	One of these three may be possible in hot climate zones
Overhangs/exterior shading devices	X	
Integrated Landscape	X	
Water Heating		
Water Heater Energy Factor upgrade		Appropriate when unit is performing poorly
Tank Insulation	X	If not yet installed
Pipe Insulation		Accessibility issues
Appliances		
Low-Flow Showerheads / Faucets	X	If not yet installed
Refrigerator		
Efficient Washer & Dryer		
Efficient Dishwasher		
Pool Pump Motor	X	Controls could be required if not already present

Table 15: Single Family Measures for Resale Events

During building refinance, both an educational and a financial opportunity are presented. In many cases there is the opportunity to convert equity into low-interest, tax-deductible capital that can be used for energy efficiency improvements. If a HERS evaluation were required during building refinance, and tied to an Energy Efficient Mortgage, improvements could be made by the homeowner that the homeowner might not otherwise consider. It is not in the Energy Commission's current authority to require inspection at the time of home refinance. If the Legislature were to create this authority, it might also make sense to require certain very basic upgrades to the structure, if they're not already present.

Many times homes are not refinanced as part of a home improvement plan, but rather to capture a favorable interest rate or to liquidate some equity. In those cases, the homeowner may strongly object to being obligated to conduct an energy inspection or complete subsequent improvements.

Possible Efficiency Measures at REFINANCE Trigger Event - Single Family Building

Measure	Candidate Measure	Comments
Integrated Measures		
HERS Rating	X	Best Candidate for this Trigger Event
HERS Rating and Building Upgrade	X	Good Candidate for this Trigger Event
HVAC		
Air Conditioning Plant Efficiency Upgrade		
Boiler or Furnace Upgrade		
Blower Fan Efficiency		
Refrigerant Charge and Air Flow measurement	X	
Equipment "Right" sizing		
System type change		
Install Evaporative Cooler or Pre-cooler		
Duct Insulation		
Duct Testing, Sealing, and Retesting	X	
Ceiling Fan	X	
Whole House Fan	X	
Programmable Set Back Thermostat		
Lighting		
Increase efficiency of hardwired systems		
Medium base socket CFLs		
Pin-based CFLs		
Maximize Daylighting		
Install/Upgrade Lighting Controls		
Building Envelope		
Cool Roofs		
Radiant Barier		
Roof / Attic Insulation		
Floor Insulation		
Air Infiltration Testing, Sealing, and Retesting		
Wall Insulation		
Window U-factor		
Window SHGC		
Sunscreens		
Overhangs/exterior shading devices		
Integrated Landscape		
Water Heating		
Water Heater Energy Factor upgrade		
Tank Insulation		
Pipe Insulation		
Appliances		
Low-Flow Showerheads / Faucets		
Refrigerator		
Efficient Washer & Dryer		
Efficient Dishwasher		
Pool Pump Motor		

Table 16: Single Family Measures for Refinance Events

5.3.3 Measures Review for Multifamily Buildings

As with single-family buildings, the alteration trigger event provides the longest and most promising set of potential measures. This is because there is a proven, existing working mechanism in place and time of alteration is the most logical time to consider related energy efficiency measures.

Possible Efficiency Measures at ALTERATION Trigger Event -- Multifamily Buildings

Measure	Candidate Measure	Comments
Integrated Measures		
HERS Rating		
HERS Rating and Building Upgrade		
HVAC		
Air Conditioning Plant Efficiency Upgrade		Appropriate when unit is performing poorly
Boiler or Furnace Upgrade		Appropriate when unit is performing poorly
Blower Fan Efficiency		More appropriate for appliance standard
Refrigerant Charge and Air Flow measurement	X	If unit is a candidate for retrofit and HVAC system is involved
Equipment "Right" sizing	X	If unit is being replaced as part of the alteration
System type change		Not likely due to logistical problems
Install Evaporative Cooler or Pre-cooler		If unit is a candidate for retrofit and HVAC system is involved
Duct Insulation		
Duct Testing, Sealing, and Retesting		
Ceiling Fan	X	
Whole House Fan		
Programmable Set Back Thermostat		Already covered under alteration requirements
Lighting		
Increase efficiency of hardwired systems	X	
Medium base socket CFLs		
Pin-based CFLs		
Maximize Daylighting	X	In common building areas upon roof replacement
Install/Upgrade Lighting Controls		
Building Envelope		
Cool Roofs		
Radiant Barier		
Roof / Attic Insulation	X	Upon reroofing
Floor Insulation		
Air Infiltration Testing, Sealing, and Retesting		
Wall Insulation	X	Possible for re-painting projects in which the wall is opened
Window U-factor		Already covered under alteration requirements
Window SHGC		Already covered under alteration requirements
Sunscreens		
Overhangs/exterior shading devices	X	Could be required in some climate zones -- tied to bldg orientation
Integrated Landscape		
Water Heating		
Water Heater Energy Factor upgrade		Appropriate when unit is performing poorly
Central Water Heating Controls	X	If not already installed when boiler is replaced
Tank Insulation		
Pipe Insulation	X	On recirc systems if not already installed when boiler is replaced
Appliances		
Low-Flow Showerheads / Faucets	X	
Refrigerator		
Efficient Washer & Dryer		
Efficient Dishwashers		
Pool Pump Motor		Planned for appliance efficiency standard

Table 17: Multifamily Measures for Alterations Events

In the case of multifamily buildings, the sale event is much like the refinance event. The building owner is not the occupant, so there is less motivation to make improvements during a sale or refinance, particularly if they are not part of a larger effort involving alteration. Given expanded CEC authority, an inspection involving a customized list of suggested energy improvements to the building could be required and would constitute a good candidate measure. Requiring minimum upgrades that are low cost and cost effective could also be considered at this time.

Possible Efficiency Measures at SALE or REFINANCE Trigger Event -- Multifamily Buildings

Measure	Candidate Measure	Comments
Integrated Measures		
HERS Rating	X	Best Candidate for this Trigger Event
HERS Rating and Building Upgrade	X	Good Candidate for this Trigger Event
HVAC		
Air Conditioning Plant Efficiency Upgrade		
Boiler or Furnace Upgrade		
Blower Fan Efficiency		
Refrigerant Charge and Air Flow measurement	X	
Equipment "Right" sizing		
System type change		
Install Evaporative Cooler or Pre-cooler		
Duct Insulation		
Duct Testing, Sealing, and Retesting	X	
Ceiling Fan	X	
Whole House Fan		
Programmable Set Back Thermostat		
Lighting		
Increase efficiency of hardwired systems	X	Outdoor and common area lighting
Medium base socket CFLs		
Pin-based CFLs		
Maximize Daylighting		
Install/Upgrade Lighting Controls		See Building and Grounds Measures below
Building Envelope		
Cool Roofs		
Radiant Barier		
Roof / Attic Insulation	X	Possible measure - small market share
Floor Insulation		
Air Infiltration Testing, Sealing, and Retesting		
Wall Insulation		
Window U-factor		
Window SHGC		
Sunscreens		
Overhangs/exterior shading devices		
Integrated Landscape		May be too time consuming for this event but could require submission of a shading plan and schedule
Water Heating		
Water Heater Energy Factor upgrade		Appropriate when unit is performing poorly
Central Water Heating Controls	X	
Tank Insulation		
Pipe Insulation		
Appliances		
Low-Flow Showerheads / Faucets	X	
Refrigerator		
Efficient Washer & Dryer		
Efficient Dishwashers		
Pool Pump Motor	X	Install more efficient motor or controls if below threshold

Table 18: Multifamily Measures for Sale or Refinance Events

The rental trigger event in multifamily buildings occurs frequently but addresses only a small fraction of the building area at a time. In addition, the vacancy time frame is typically short and would not invite improvements that were beyond necessary repairs. There is also typically no economy of scale provided for these improvements, as units are vacated and rented unpredictably.

Possible Efficiency Measures at RENTAL Trigger Event -- Multifamily Buildings

Measure	Candidate Measure	Comments
Integrated Measures		
HERS Rating		
HERS Rating and Building Upgrade		
HVAC		
Air Conditioning Plant Efficiency Upgrade		
Boiler or Furnace Upgrade		
Blower Fan Efficiency		
Refrigerant Charge and Air Flow measurement	X	
Equipment "Right" sizing		
System type change		
Install Evaporative Cooler or Pre-cooler		
Duct Insulation		
Duct Testing, Sealing, and Retesting	X	
Ceiling Fan	X	
Whole House Fan		
Programmable Set Back Thermostat		
Lighting		
Increase efficiency of hardwired systems		
Medium base socket CFLs	X	
Pin-based CFLs		
Maximize Daylighting		
Install/Upgrade Lighting Controls	X	Photocell at patio or porch
Building Envelope		
Cool Roofs		
Radiant Barier		
Roof / Attic Insulation		
Floor Insulation		
Air Infiltration Testing, Sealing, and Retesting		
Wall Insulation		
Window U-factor		
Window SHGC		
Sunscreens		
Overhangs/exterior shading devices		
Integrated Landscape		
Water Heating		
Water Heater Energy Factor upgrade		Federal standard applies
Central Water Heating Controls	X	If not already installed
Tank Insulation		
Pipe Insulation		
Appliances		
Low-Flow Showerheads / Faucets	X	If not already installed
Refrigerator		
Efficient Washer & Dryer		
Efficient Dishwashers		
Pool Pump Motor		

Table 19: Multifamily Measures for Rental Events

5.3.4 Measures Review for Commercial Buildings

Commercial alterations constitute a seven billion dollar per year industry in California. Current standards mechanisms capture a good deal of the efficiency opportunities presented by that active market. However, there is still a good deal of potential to look at logical expansions of current regulations (all under existing authority) and expansion of authority to regulate related measures and systems during remodel.

Possible Efficiency Measures at ALTERATION Trigger Event -- Commercial Buildings

Measure	Candidate Measure						Comments
	Office	Retail	Grocery	Restaurant	Warehouse	School	
Integrated Measures							
Commissioning	X	X	X	X	X	X	Good event for this trigger
HVAC							
Air Conditioning Plant Efficiency Upgrade							Appropriate when unit is performing poorly
Boiler or Furnace Upgrade							Appropriate when unit is performing poorly
Testing Adjusting and Balancing	X	X	X	X	X	X	Currently Covered for 10 HP or greater TAB could be part of commissioning and include sheave replacement. Appropriate for HVAC alteration
Install Variable Speeed Drive							Currently Covered for 10 HP or greater
Install Evaporative Cooler or Pre-cooler							Installation quality issues
Install Economizer							
Economizer Testing and Fault Detection	X	X	X	X	X	X	Could be required for existing economizers when HVAC system is altered
Duct Testing, Sealing, and Retesting							Already covered under alteration requirements
EMS	X	X	X	X	X	X	Calibration/ tuning of setpoints when HVAC system is touched
Lighting							
De-lamp							Probably not applicable for this trigger event
Task Lighting							
Increase luminaire efficacy							Already covered under alteration requirements
Maximize Daylighting			X				Not currently required. First cost is high - Big box skylights required if building previously unconditioned
Install/Upgrade Lighting Controls	X	X	X		X	X	Automatic bi-levelor other controls currently not required could be required when lighting systems are altered. Very effective in Warehouse and School occupancies
Building Envelope							
Cool Roofs	X	X	X	X	X	X	Could be expanded to include more roof types
Radiant Barrier	X					X	if applicable per the type of structure
Roof / Attic Insulation	X	X	X	X	X	X	Upon reroofing is best
Wall Insulation							Already covered under alteration requirements if envelope is altered
Window U-factor							Already covered under alteration requirements if envelope is altered
Window SHGC							Already covered under alteration requirements if envelope is altered
Overhangs/exterior shading devices							Possibly in conjunction with window addition
Integrated Landscape							Possibly in conjunction with window addition
Water Heating							
Water Heater Energy Factor Upgrade							Already covered by appliance efficiency standards
Tank Insulation	X	X	X	X	X	X	Could be considered during a related event (replacement of boiler) for small systems
Pipe Insulation	X	X	X	X	X	X	Could be considered during a related event (replacement of boiler) Authority for water heating systems could be extended to unconditioned buildings.
Appliances							
Vending Machines							

Table 20: Commercial Measures for Alteration Events

The resale trigger event could provide an opportunity for an overall building evaluation and tune up. Although not in current CEC authority, there are some cost effective measures that could be evaluated if such authority were granted.

Possible Efficiency Measures at RESALE Trigger Event -- Commercial Buildings

Measure	Candidate Measure						Comments
	Office	Retail	Grocery	Restaurant	Warehouse	School	
Integrated Measures							
Commissioning	X	X	X	X	X	X	Best Candidate for this Trigger Event
HVAC							
Air Conditioning Plant Efficiency Upgrade							
Boiler or Furnace Upgrade							
Testing Adjusting and Balancing	X	X	X	X	X	X	Replacing sheaves is reasonable adjustment to fan efficiency
Install Variable Speeed Drive							
Install Evaporative Cooler or Pre-cooler							
Install Economizer							
Economizer Testing and Fault Detection	X	X	X	X	X	X	Part of commissioning
Duct Testing, Sealing, and Retesting							
EMS							
Lighting							
De-lamp							
Task Lighting							
Increase luminaire efficacy	X	X	X	X	X	X	
Maximize Daylighting							
Install/Upgrade Lighting Controls	X	X	X		X	X	Very effective in Warehouse and School occupancies
Building Envelope							
Cool Roofs							
Radiant Barrier							
Roof / Attic Insulation	X	X	X	X	X	X	This is difficult for suspended grid ceilings. Only cost effective if no or minimal insulation present
Wall Insulation							
Window U-factor							
Window SHGC							
Overhangs/exterior shading devices							
Integrated Landscape							
Water Heating							
Water Heater Energy Factor Upgrade							
Tank Insulation	X	X	X	X	X	X	Could be considered for small systems
Pipe Insulation							
Appliances							
Vending Machines							

Table 21: Commercial Measures for Resale Events

Building lease often involves an alteration that already evokes the Building Energy Efficiency Standards. But when it does not, expansion of the scope or authority of the standards to accommodate this would be required for the measures shown below to be possible as mandates.

Possible Efficiency Measures at Occupancy Change Trigger Event -- Commercial Buildings

Measure	Candidate Measure						Comments
	Office	Retail	Grocery	Restaurant	Warehouse	School	
Integrated Measures							
Commissioning	X	X	X	X	X	X	Good event for this trigger if mechanism is developed
HVAC							
Air Conditioning Plant Efficiency Upgrade							
Boiler or Furnace Upgrade							
Testing Adjusting and Balancing							TAB requirement on change of occupancy - even if alteration is lighting only - could include changing sheaves.
Install Variable Speeed Drive							
Install Evaporative Cooler or Pre-cooler							
Install Economizer							
Economizer Testing and Fault Detection	X	X	X	X	X	X	Mechanism is needed but potential is great
Duct Testing, Sealing, and Retesting							
EMS							
Lighting							
De-lamp							
Task Lighting							
Increase luminaire efficacy							
Maximize Daylighting							
Install/Upgrade Lighting Controls	X	X	X		X	X	Possible candidate for wireless controls
Building Envelope							
Cool Roofs							
Radiant Barrier							
Roof / Attic Insulation							
Wall Insulation							
Window U-factor							
Window SHGC							
Overhangs/exterior shading devices							
Integrated Landscape							
Water Heating							
Water Heater Energy Factor Upgrade							
Tank Insulation	X	X	X	X	X	X	Could be considered for small systems
Pipe Insulation							
Appliances							
Vending Machines							

Table 22: Commercial Measures for Lease Events

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